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ABSTRACT

This paper advocates the extensive use of case studies in engineering materials course instruction. The author states that increased enthusiasm can be generated for what is generally considered to be a dull subject by the inclusion of actual engineering problems. To document this, a narrative of three materials courses using differing numbers of case studies is provided. (CP)

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INTEGRATION OF FAILURE ANALYSIS AND CASE STUDIES IN MATERIALS COURSES

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Increased interest in materials courses can be generated by inclusion of case studies in failure analysis and design. This is particularly true in required courses for which students often show little enthusiasm. An additional advantage is that the student has the opportunity to deal with real situations to which he can not only directly relate but can "second guess" the original solution. The paper discusses three materials courses, ranging from one with a few cases used as supplements to courses using only cases.

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Why Use Case Studies?

Theory is better understood by most people after seeing examples of application. Authors of good textbooks recognize this by including examples of application of established theories. Cases present additional dimensions: 1, they not only show application of theory but also show how engineers went about the application; and 2, they introduce circumstances which are not pertinent to a "pure" model of the situation but are found regularly in engineering practice. Recognition of this situation may well be useful to future engineers.

Although the methodology of deductive logic is very useful for teaching many engineering subjects, case studies are preferable in teaching selection and application of materials since they encourage the necessary mental flexibility. The instructor must abandon the illusion that he can teach all there is to know about the subject. The student, likewise, must abandon the illusion that he will have been exposed to the whole subject. In compensation, the focus can be broadened well beyond theory since a number of factors are involved, such as design aspects, litigation potentials, engineering responsibilities, economics, etc., all of which bear on engineering practice. Class discussion gives students an opportunity to present and defend a viewpoint in opposition to a "hostile" one. Students also come to recognize that there may be a number of possible solutions to any given problem with perhaps little choice among them.

Required First Course in Materials

The University of Detroit requires all undergraduate engineers to take an interdepartmental course in Engineering Materials. This is a four-semester-hour course (normally taken in the second semester of the Junior year)

calling for two lectures, one recitation session, and a two-hour laboratory period each week. Case studies have been used for some of the laboratory exercises.

All cases used so far have dealt with problems in failure analysis (some involving litigation) of items of "hardware" with which the student can at least visualize an association. One case, for example, dealt with "hard hats" which were failing in storage as well as in service. Those students who have not worn such a hat on cooperative education work experience at least know what they are and have no difficulty in visualizing wearing one.

In this context, four different cases have been used. For each one, a portion of the written material is distributed a week in advance. This material covers background information, various data and observations, photographs, drawings and questions to help focus student effort. Each student is expected to analyze the situation and to formulate his analysis and solution in writing. During the laboratory period, these positions are discussed among the students with plenty of interaction as it becomes obvious that viewpoints differ. After some discussion, the students have jointly worked out a good analysis of the situation and some possible solutions. The rest of the written material is then distributed so that the students have the complete story of the case as it was handled in actual practice.

The students seem to have been much more receptive to these cases as laboratory exercises than to the more traditional exercises still used, such as tensile testing, etc. They seem much more likely to stay around after class dismissal to continue discussion on a point or to extrapolate to some situation of personal experience.

They also seem much more likely to ask questions during the recitation period about matters which are clearly related, although somewhat tangential, to the assigned subject matter. I am convinced that many of them come to see the materials course as having a relationship to practical matters--certainly more than a theoretical, science-oriented course.

Materials and Design

One semester, a few Seniors were interested in continuing work in materials after the required first course. After some discussion, it was agreed that a course would be offered on a "one-time" basis using case studies exclusively, all of which would involve materials in design situations. In this situation, the class of eight students met once a week for two to three hours. An assignment of a case study was given with appropriate questions to be discussed at the next class meeting. The students were free to discuss with each other and were encouraged to use the library and other sources of information. When the class met, there was a healthy discussion. Although I have no doubt there had been discussion during the week, there were no "carbon copy" answers.

The cases used included failures in heavy-duty rippers and scrapers for tractors, failures in welded joints in hopper trailers, truck suspension failures, fracture of a large marine gear rim (failure during fabrication), design and fabrication of a seawater test chamber, and development of a new steel for rock drills. All of these cases were in two or more sections with one section being discussed each class session. At the end of each session, the situation was summarized and the next assignment given. If the session ended a given case,

the rest of the written case study describing the actual solution was given to the student with a quick verbal summary by the instructor.

Obviously, quite a number of cases were covered. It is true that none was covered completely (one could conceivably spend several sessions, even an entire semester, on only one case by exploring different facets in depth) but the students did get a good exposure to the kinds of problems that one encounters because of the intimate relationship among design, choice of materials, and fabrication of equipment for practical uses.

Class attendance and participation stayed high throughout the semester. Student reaction to this approach (new and different to each student compared with previous classroom experience) was unanimously favorable. This does not surprise me, since the course was an elective and each student had full opportunity to participate with his view getting full consideration from the other students and the instructor.

Advanced Engineering Materials

In the fall of 1973, the graduate engineering materials course had five enrollees. Cases were used in somewhat the same manner as the earlier elective in "Materials and Design" although there was no preconceived sequence in comparison with the earlier senior course. In the graduate context, some of the cases used as laboratory exercises in the junior course and in the earlier senior elective were used. Obviously, student analyses and proposed solutions were expected to be more sophisticated (and generally were). As the discussion of a given case developed, questions and issues would develop which were not immediately resolved. At the end of the class session, these issues were

summarized with the students expected to do some "research" in order to resolve them the next session. This worked well. For example, the question of fatigue developed in discussing one of the early cases. This led to enough exploration into fatigue that more than two weeks were spent on the subject. There was mutual agreement that this time was well spent.

At the end of the semester, there was complete agreement among the students that the use of case studies, exploration of tangential, but pertinent, issues, with active student participation was a pleasant and profitable procedure.

Reaction to Use of Cases

I am convinced that use of cases stimulates student interest. In the junior level required course, not every student was stimulated, but I am convinced that collective student interest was increased by use of cases in comparison with earlier courses which did not use cases. In elective courses, I believe that use of cases stimulates and maintains high student interest. I believe students get more insight into application of materials and thus better understand the necessity for studying materials theory which provides the basis for application.

Comments for Teachers

I like the flexibility of formulating various questions to focus attention in any desired direction or to emphasize any desired aspect at any desired depth or level, especially in the context of a practical problem posed by a good case study. In doing this, the teacher must recognize that he will not be in the usual comfortable position of expounding to the students but may well be in the position of not being able to answer some pointed and penetrating questions. This can be a good learning experience for

the instructor!

It takes most students a few weeks to adjust to the discussion give-and-take approach using cases. The greatest benefit is thus obtained if a number of cases (one or two sessions per case) are used. In this context, use of only case is not advisable. If an instructor has never used cases, there is an understandable hesitancy to use them. After one has had experience with case studies, be he student or instructor, he discovers that their use can be an enjoyable, even exciting, experience.

Most of the cases used in the courses sketched above have been obtained from the Stanford University Engineering Case Library. Cases are, however, available from a number of sources (Appendix I). One can also write his own cases, either from his own experience or other sources. As an example of the latter, page 79 of Metal Progress for October 1973 has an example which involves questions of material selection, design configuration and cost which might well be recast as a problem for student solution.

GIVE CASE STUDIES A GOOD TRY AND HAVE FUN!

Appendix I

Sources of Cases

The major sources of engineering cases for educational purposes is:

Engineering Case Library
Stanford University - Room 500
Stanford, California 94305

Engineering cases are also available from other sources. The following lists may be useful:

Selected Cases in Business Administration, 1967, $10.00. (List 2900 cases, including several hundred on Production).

Cases in Research and Development

Cases in Technological Change and Automation

from:

Inter-University Case Program, Inc.,
607 University Ave.
Syracuse, N. Y. 13210

Index and Summary of Case Studies
(includes 14 engineering cases, mainly connected with public administration)

from:

Public Relations Division
Western Electric,
195 Broadway, N.Y. 10007

Cases produced in graduate design courses from:

Professor R. Steidel, Jr.
Dept of Mechanical Engineering
University of California
Berkeley, California 94720

Professor C. O. Smith
Dept of Mechanical Engineering
University of Detroit
4001 W. McNichols Rd
Detroit, MI 48221